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Talk given at
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During
Engineers' Week
by
Elliot Mitchell
of
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I appreciate the opportunity to join in the observance of Engineers' Week with you here at Huntsville. As the home of Redstone Arsenal, Huntsville looms large on the map of any engineer -- especially one such as myself who is in the space engineering business.

The theme used in this observance -- Engineering Challenges of the 1960's -- is most appropriate. While it would take a visionary with an extremely well-polished crystal ball to point out, in detail, the nature of the engineering problems with which we shall be wrestling later on in this challenging decade, it is clear that it will take the marshalling of our best talent and effort to solve them. I am equally convinced that the resulting progress will exceed that of any prior decade.

It has become increasingly evident in recent weeks that the Congress and the nation overwhelmingly support the President's recommendation that the Development Operations Division of ABMA be transferred to NASA.

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A resolution to declare Congressional approval of the transfer received speedy approval in the House and is under consideration in the Senate. It would make Congressional support of the transfer positive instead of passive. In the interest of effecting an orderly transfer which will disrupt the national space program as little as possible, however, the Department of the Army and NASA have agreed that the transfer shall become finally effective on July 1, 1960.

Since many of you here will be associated with NASA in the future and I am sure all of you will be affected, in one way or the other, by this change, I believe it would be appropriate for me to spend a few minutes this evening briefly describing the National Aeronautics and Space Administration -- its facilities, manpower, and budget. Secondly, I would like to outline the particular role that the NASA facility at Huntsville will be playing during this coming decade and beyond in the engineering job ahead of us and lastly, I would like to present some thoughts on what I feel are the obligations of engineers and scientists in this major scientific and engineering effort beyond the immediate objective of solving our technical problems.

The National Aeronautics and Space Administration is not yet quite 18 months old. Fortunately, it was founded on the solid engineering and research achievement of the National Advisory Committee for Aeronautics when it became operational on October 1, 1959 -- just two months after the President signed into law the National Aeronautics and Space Act. NACA provided the new NASA with about 8,000 well-trained, experienced scientists and technicians and a substantial complex of excellent facilities.

The three former NACA centers constitute the principal in-house advance research capability for NASA and report to the Headquarters Office of Advanced Research Programs.

Langley Research Center at Hampton, Virginia, is primarily occupied with research in structure and materials, reentry aerodynamics, and in plasma physics. The Lewis Center at Cleveland is investigating propulsion problems with principal programs in advanced research on chemical rockets including high energy propellants, nuclear rockets, electrical propulsion devices, and power generation in space. At the Ames Center in the Santa Clara Valley of California, the principal areas of work are space environmental physics including simulation techniques, gas dynamics research at extreme speeds, and automatic guidance and control of space vehicles. A small but highly specialized facility is the Flight Research Center at Edwards, California, now concentrating most of its efforts on the X-15 flight evaluation program.

There were areas in which the old NACA was not working and in which NASA had to become deeply involved to accomplish its mission. To acquire a capability in these areas, we could have started from scratch, building, equipping and staffing new facilities. This would have been expensive and time consuming. Or we could integrate into a single organization the facilities already doing outstanding work in the areas where we were lacking. This course was chosen.

It brought to NASA the Jet Propulsion Laboratory in Pasadena, California, whose reputation is well known to you here in Huntsville after JPL's excellent contributions to ABMA's efforts in the Explorer program. JPL manages one major area of spacecraft development for NASA -- the exploration of deep space, including lunar and interplanetary probes.

Primary responsibility for the other major spacecraft development area -- earth orbiting craft -- is lodged with the Goddard Space Flight Center. Staff of Goddard is built around a nucleus of the Vanguard team also transferred to NASA at its inception. JPL and Goddard function under the Headquarter's Office of Space Flight Programs.

The President's decision to give NASA full responsibility for all super booster development pointed up another lack in our capability. We needed a highly imaginative and competent engineering and design group, capable of serving as an integral part of the NASA organization in the planning and executing of both short and long-range programs in the development of launch vehicle systems. We wanted such a group also to monitor contracts with other governmental agencies and with industry, and to provide necessary ground testing and assembly capability -- and finally, to supervise space vehicle launching operations for NASA.

The requirements we sought to satisfy are possessed in an outstanding manner by the von Braun group at Huntsville. The acquisition of the von Braun group has paved the way for the centralization at Huntsville of the major responsibility for the bulk of NASA's launch vehicle systems development and operations.

Subsequent actions indicate the importance attached to this activity within the NASA complex. One is the establishment at Headquarters of the new office of Launch Vehicle Programs under Major General Don R. Ostrander. Ably supporting General Ostrander as Deputy is Abraham Hyatt. Organization of this new Headquarters division began the first of the year and, although complete staffing is not quite completed, I can assure you that the vital launch vehicle program under our direction is being energetically pushed forward.

One example, to which Dr. von Braun alluded in his recent appearance before the House Space Committee, will suffice: Just a little more than a month after the President announced his intention to transfer the von Braun group to NASA, Dr. Glennan, NASA's Administrator, approved a report of the so-called Saturn Vehicle Team recommending all high energy liquid (H_2-O_2) upper stages for the Saturn vehicle. Implementation of that decision is now underway as a result of bidders conferences held recently at Huntsville and in Washington Headquarters.

Since the technical direction of the Saturn program was assigned to NASA, the project has been given the highest national priority, and work is being accelerated with increased overtime wherever needed.

Another evidence of the vital importance of Huntsville's role in the launch vehicle program is the fact that our budget estimates show that more than $300 million will be spent at Huntsville and with industry under Huntsville direction and administration during fiscal 1961.

A brief look at a few budget figures will indicate the financial resources available to us. For the current fiscal year, the NASA budget totals $523 million.

For fiscal year 1961, we have proposed an $802 million program and the President has recommended an additional $113 million supplement to further accelerate the super booster program, particularly Saturn. As you know, there are included in that sum funds to enlarge the booster fabrication facilities at Huntsville, to erect a second test stand at Huntsville, and to build a second launch complex at Cape Canaveral.

Predictions of future funding are risky, of course. But our Associate Administrator, Mr. Richard Horner, recently told the House Space Committee "... it is likely that a natural growth of the developments now underway will lead to a budget request of more than one billion dollars in fiscal year 1962 with a growth to more than one and one-half billion dollars a few years later".

In a funding discussion, one other important fact should be noted. In our request for new obligational authority in fiscal 1961, totaling some $915 million, less than $300 million represents in-house support including salaries and expenses and construction and equipment. More than $600 million is requested for research and development contracting with industry. Further, Dr. Glennan told the House Space Committee that of the total 12 to 15 billion dollars that will be spent for space exploration over the next decade, "we estimate that approximately 75 percent of our budget will be expended through contracts with industry, educational institutions, and other non-governmental groups".

Now, turning to my own field of specialty, propulsion, I would like to discuss some of the challenging engineering jobs which you now are facing here at Huntsville and more particularly which you will be facing in the future.

The main immediate engineering challenge now apparent at Huntsville -- the Saturn first stage booster -- appears well in hand. Every day new hardware points up the fact that progress is being made toward erecting Saturn on its Cape Canaveral launch pad. I do not have to repeat the importance and import that successful completion of this job has, not only to our space effort, but to our political and technical stature in the world.

It is only in recent months that the challenges of the ultimate - fully staged Saturn vehicle have become apparent. With the decision to take fullest possible advantage of the immense power of the Saturn booster by use of high energy H_2-O_2 upper stages, our work, spearheaded by you here at Huntsville, was laid out for us.

You are familiar, I think, with the first phase of the job -- the development of a second stage for the C-1 vehicle -- to be powered by four uprated 20,000 lb. thrust liquid oxygen-liquid hydrogen engines of the Centaur type and the integration of that stage with the booster and the Centaur-type third stage. That program will be underway shortly under Huntsville direction.

A next step in the Saturn building-block program also is underway. On February 3rd, there was held at NASA Headquarters a technical briefing for prospective bidders on a 200,000 pound thrust liquid oxygen-liquid hydrogen engine. This engine will power subsequent intermediate stages for advanced Saturn vehicles. The Huntsville group participated in this briefing at which prospective bidders were told that development time for this engine through preliminary flight rating test was to be three years. It is expected that a contract will be assigned for development of this engine early in May.

Our confidence in proceeding with such an engine which has a higher rated thrust than the basic Atlas engine on a 3-year time scale, reflects a dramatic progress and success in the use of liquid hydrogen, which was little more than a laboratory curiosity not too many years ago.

The engineering accomplishments of American scientists and engineers in learning how to manufacture and handle liquid hydrogen on a thousands of pounds scale economically and reliably, and developing practical and reliable engines based on this exotic propellant is a success story which will have to be told in detail at some later date.

The availability of the engine is only part of the task. To Huntsville and American industry now falls the exacting and crucial task of designing and building reliable stages, and integrating them into a practical and highly reliable vehicle; and this on a time scale that requires that first decisions be the right decisions.

Use of high energy upper stages with the powerful Saturn booster will enable us to take some giant steps forward in our space exploration program. The initial configuration will enable us to put around 12 tons into a nominal earth orbit or four tons into the vicinity of the moon. The second configuration will lift more than 22 tons on earth orbit missions and have more than double the capability of the initial vehicle for deep space missions.

The first operational flight of Saturn will come sometime in 1964 under present plans after ten previous development flights.

By 1967, the use of Saturn will have gained us the capability of placing into earth orbits payloads 25 times as heavy as those of today -- using the 2,000 pound Mercury capsule as representative of today's capability.

The next significant increase in payload capability is believed to be attainable late in the decade through introduction of a Nova type vehicle. And here again, a large engineering challenge awaits the Huntsville team. Responsibility for development of the Nova vehicle will rest with Huntsville and it will be a weighty one. The development of this vehicle will be one of the crucial steps in our space exploration program for the next decade because, with Nova, we will achieve for the first time the capability of launching a vehicle from the earth that can carry a man to the moon and return him to earth.

Work already is underway on the basic power plant for this vehicle. Just a few months after NASA became operational, a contract was signed with the Rocketdyne Division of North American Aviation for development of the F-1 engine -- a single-chamber, lox-RP-1 engine capable of 1.5 million pounds thrust. A full-scale soft mockup of the engine has been completed and, using a full-scale uncooled combustion chamber, stable combustion has been achieved at more than one million pounds of thrust.

By 1964 or 1965, the Huntsville team will be beginning the first serious hardware work on translating this huge engine into an integrated vehicle. One possible configuration recently presented to the House Space Committee shows both the engineering challenges involved in this huge job and some of the pay-offs that can be expected when those challenges are overcome.

This configuration assumes the clustering of six of the F-1's for the first stage booster achieving somewhere around nine million pounds thrust. The vehicle would have a 44-foot diameter base and stand some 220-feet high. Its capabilities are projected at about 290,000 pounds for a nominal earth orbit; 60,000 pounds for a 24-hour orbit; and some 100,000 pounds for a lunar probe.

While we are even now designing potential configurations of Nova, I must emphasize that we are in the infancy of design and use of large thrust boosters and the vehicles associated with such boosters. The progress in propulsion and vehicle technology over the next 5-7 years will be such that one of the major challenges to vehicle designers will be the ability to steer that difficult course between use of the established, though perhaps less economic and inefficient techniques, and change to more advanced and perhaps more economic, though less tried, systems. It is difficult to foresee now, in detail, the decisions we will be facing between chemical liquid or solid rockets, nuclear systems, or electrical rocket concepts. Suffice it to say that we recognize <u>now</u> that these decisions will have to be made, that they will be difficult, and that in the meantime, we are pressing urgently forward on all these fronts to expand state-of-the-art background so that when these decisions must be made, the engineering data will be available.

Along these lines, it is becoming evident that progress on feasibility and development of large solid boosters is making rapid strides, and we must explore carefully to assure that we will be prepared to exploit this capability, if advantageous, in future vehicles.

Other engineering challenges looming ahead for the Huntsville team for the remainder of the decade go beyond today's reliance on chemical rockets. But, as I will point out in a moment, we will rely heavily on today's propulsion concepts in proving out tomorrow's advanced concepts.

A large part of our advanced propulsion technology program today is aimed at meeting future requirements with two basic types of propulsion systems on which we are hard at work. These are the nuclear heat transfer rocket and the electrical propulsion rocket. In the nuclear heat transfer rocket liquid hydrogen is heated in a nuclear reactor to temperatures sufficient to give specific impulses exceeding 700 pounds of thrust per pound per second of propellant flow. The basic principle of the electric propulsion rocket, the other type system in which we are increasingly active, is to use electrical power to eject a propellant at very high velocity. With such devices impulses exceeding 20,000 pounds thrust per pound per second of propellant flow are achievable.

Out interest in both the nuclear heat transfer rocket and in the nuclear electric rocket stems from the high specific impulse of these systems which permits the delivery of large payloads over the long range interplanetary missions. For example, a 150,000 pound spacecraft taking off from an earth orbit to orbit Mars and return to the earth orbit could return with 3000 pounds if it is a high impulse chemical rocket, 20,000 pounds if it is a nuclear rocket, and possibly 30,000 pounds if it is an electric rocket, using a nuclear electric power source.

An aggressive joint program between NASA-AEC is now active on the nuclear heated rocket with AEC developing the nuclear reactor and NASA sponsoring the development of associated rocket components. The integrated AEC-NASA nuclear rocket program will continue through development of a flight test engine, development and operation of the flight test vehicle and finally, the application of nuclear rockets to useful missions. This program is making excellent progress, and design studies are now underway at NASA and will be also initiated in private industry this fiscal year to evaluate the best methods of flight testing nuclear rocket systems. The rate of planned progress calls for flight tests of such a system during the second half of this 1960 decade. Extensive useful applications of such a nuclear rocket should develop during the early 1970's.

One promising flight test configuration involves use of Saturn. The two-stage Saturn vehicle is used to boost a nuclear rocket stage into earth orbit. After the stage is in orbit it could be started up and tested under conditions that simulate conditions which would be encountered in accomplishing an actual long range mission. Such an orbital nuclear rocket stage could be a low thrust, low reactor power system. On the Saturn vehicle, for instance, a reactor power of 200 megawatts would be sufficient.

Needless to add, the Huntsville team's involvement in a flight test program for the nuclear rocket will be a heavy one.

In the field of electrical propulsion the NASA Research Centers have been conducting research for several years on ion and plasma rockets and on the nuclear - electric power supplies which will be required to operate them. At ABMA, Dr. Ernst Stuhlinger was one of the first to recognize the potential of ion rockets and the Army has actively supported industrial research contracts on ion rockets and arc plasmajets for about two years. The development of such devices requires research and the most imaginative engineering in many advanced fields such as plasma physics, magnetohydrodynamics and high temperature materials.

The NASA realizes the necessity of rapidly advancing the technology of electrical propulsion by increasing the degree of participation by industry in this field. Therefore in the next 1-2 months, several NASA contracts will be awarded for applied research and component development of ion rocket and arc plasmajet propulsion devices. We plan to assign responsibility for technical direction of these and of future NASA contracts on electrical thrust devices to our Huntsville activity.

This will be an area of increasing effort and expenditure over the foreseeable future. In particular, we foresee the availability of ion and plasmajet systems at useful thrust levels which will be flight tested in the 1965-1966 period. We are confident that the many difficult development and engineering problems in this area can be solved by industry and von Braun's group under the able guidance of men like Dr. Stuhlinger with active supporting research by the NASA Research Centers.

Another important area in our program is aimed at development of electrical power generating systems to supply both propulsion and auxiliary power requirements. In addition to power for electrical propulsion requirements, auxiliary power will be needed in every spacecraft to carry out the wide range of functions for spacecraft control, support of personnel, information transmissions, etc.

Progress is being made but a vast number of engineering challenges remain in this program. Progress in developing a thermoelectric system was shown in the demonstration of the small SNAP-3 power generator about a year ago.

Another project, on which NASA is now evaluating proposals, is for development of a nuclear electric power generating system. Designated as SNAP-8 and conducted jointly with AEC, this system will generate 30 kilowatts. In this system, heat from the reactor is used to boil liquid metal which drives a turbine. The turbine drives a generator and all the pumps needed in the system. One problem in this system is that at least 80% of the heat cannot be used and must be rejected from the system. In space and where large powers are required, radiators having surfaces equivalent to football fields will be required and methods of packaging them during launch and erecting them in orbit must be developed.

It is in the growing research and development programs on these advanced propulsion and power systems that we may reap some of the very significant advantages of the space program. For example, the development of the compact reactor for electric generating systems required for the electric rockets will result in a substantial increase in liquid metal technology and "know-how" at temperatures up to 2000-2500F as compared with the present state-of-the-art up to temperatures of 1200-1500F. Such increased temperatures would permit the development of small, light weight, high power density systems for commercial application far beyond our present capability. It is to be anticipated that the extremely demanding technological requirements of the space program will allow us to reap a real harvest in our earth bound civilian activities.

This brings me to a crucial aspect of our space program. The successful achievement of the goals we have described requires sustained and determined effort over many years. The cost of our program over the next 10 years may well be as much as 15 billion dollars. The successful achievement of our goals demands the continued financial and moral support from the Congress that can only come from the enthusiastic and clear mandate of the people to their Congress.

It seems to me the clear obligation of scientists and engineers associated with these programs and other technical efforts to spread an understanding, with all means they have available, of the significance of this complex and difficult task, its implications to our future, and its promise, to their associates and the people of the nation. I believe it is only from such a broad base of communication that we can develop the sustained understanding and support so vital to achieving our space research goals and also to maintaining our standing as preeminent in most scientific, technological and industrial fields.